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Abstract

METHODS OF SOLUTION OF TRANSPORT EQUATION IN INHOMOGENEOUS AND FINITE MEDIA

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The report consists of three parts. The first part is devoted to finite difference methods of solution of plane-parallel and spherical-symmetric γ-quanta and neutron transport problems in hydrogenous media. In the second part some methods for the improvement of the statistical efficiency of Monte-Carlo methods for the case of radiation transport problems in inhomogeneous and finite media are considered. The third part is devoted to the Monte-Carlo study of the neutron penetration through the resonance absorber slab.

1. To formulate a finite-difference method of solution of the integro-differential transport equation it is necessary to consider separately two problems: (a) a finite-difference representation of the differential part of the equation and the solution of the system obtained; (b) an approximate estimate of the scattering integral occurring in the equation.

In the case of plane-parallel problems the formulation of part (a) is not difficult. When the spherically-symmetric problems are investigated the method similar to the Carlson's S_n-method can be used. The difficulties due to singularities of the equation at the origin are avoided by means of the Vladimirov's characteristics method.

For the formulation of the part (b) both for the plane-parallel and spherically-symmetric problems the scattering integral is written down as a double integral along the surface of unit sphere and then evaluated using the simplest quadrature formulae so constructed that the main features of the scattering kernel and the relatively weak dependence of the directional distributions on the energy are taken into account.

In practice the energy interval is divided into sub-intervals and in each of them the spectral distribution is represented by a linear function of energy with

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coefficients depending on directional and spatial co-ordinates. At each fixed value of energy the integro-differential equation is considered to be a differential equation with a known right side. An appropriate choice of the quadrature formula for the approximate calculation of the scattering integral makes unnecessary the use of iterative procedures.

A range of applications of methods described can be extended appreciably by means of the adjoint function theory.

2. In the second part of the report problems of calculating differential angular and energy distributions of the radiation at a fixed point in space (local flux calculation method) are examined. This method proposed by Zerby and collaborators has an infinite standard deviation which considerably reduces its efficiency.

A modification of the local flux calculation method is proposed which will have a finite standard deviation for the total flux or dose rate at a point fixed in space.

Calculation of Fourier coefficients of the flux function in terms of space variables also ensures finiteness of the standard deviation.

In this case the slow convergence of Fourier series may be improved by the choice of a weighting function which takes into account the singularity of the integrand.

An application of the local flux calculation method to the problem of penetration of radiation over a small surface element is also discussed in the paper.

The mathematical aspects of the problem arising as a result of the application of random quadrature formulae of higher accuracy are discussed.

New quadrature formulae and evaluation of their errors are given.

Examples of the calculation for one-velocity problems with an isotropic scattering are given.

3. A transfer of neutrons in resonance absorber slab is considered. For this purpose the Monte-Carlo method using importance sampling of initial energies of neutrons proved to be very effective. A specially constructed function is used as an adjoint function.

This approach makes it possible to perform neutron absorption and penetration calculations for the wide range of sample thicknesses.